

SOLUTION TO Z32 CIPHER AND MAP PUZZLE

By DMW

Overview:

A solution to the famous Zodiac Z32 cipher and the Phillips 66 map puzzle associated with it is presented herein.

The solution possesses the following features:

- It utilizes information from all three available sources (the June 26, 1970 letter from the Zodiac to the San Francisco Chronicle, the Phillips 66 road map that accompanied that letter, and the post script to the July 26, 1970 Zodiac letter).
- There is nothing arcane or mysterious about this solution – nothing more complicated than high-school mathematics and simple homophonic substitution.
- It implicates Arthur Leigh Allen.
- Since the Z32 cipher has 29 unique characters in a 32 character cipher, there are many possible solutions to it. Therefore, there is no way the solution contained herein can be considered to be definitive. I believe it to be very compelling – a possible solution. It is certainly not the only possible solution.

Overview of Solution:

Assuming a simple homophonic substitution, one possible decoding of the Z32 cipher is as follows:

IN: THREE AND THREE EIGHTHS
RADIANS: TEN

Locating these coordinates on the Phillips 66 map, we find they are exactly the coordinates of Arthur Leigh Allen's home in Vallejo.

Background:

The Zodiac killer terrorized the San Francisco area in the late 1960's and early 1970's. Investigators agree that he committed five murders in 1968 and 1969, and he may have been responsible for several others. He himself claimed to have killed 37 people, though this does not seem likely. He was never apprehended.

In addition to the murders themselves, Zodiac also wrote a number of letters and placed several phone calls. These communications generally taunted the police or reporters. Several made specific threats – to shoot a bus full of school children or ignite a bomb – which apparently the Zodiac never acted upon.

* The one Zodiac cipher that was solved relied on nothing more esoteric than homophonic substitution. It is certainly possible that the Zodiac used some strange and obscure system to encode information in his other ciphers, but I think it's more likely he used a system similar to the one he had already used.

Some of the letters included cryptograms. The first of these, often referred to as the Z408 Cipher (because it was 408 characters long) was divided into three pieces which were sent to the Vallejo Times Herald, the San Francisco Examiner, and the San Francisco Chronicle on July 31, 1969. These papers published the cipher, and within about a week, school teacher Donald Harden and his wife Bettye Harden contacted the San Francisco Chronicle with the solution. The Hardens were not professional cryptographers – they simply enjoyed solving puzzles together. The decoded message turned out to be a long, rambling message about why the Zodiac liked killing.

The Zodiac sent three other cryptograms, but none of these were ever solved. These include the Z340 Cipher, the Z13 Cipher, and the Z32 Cipher, also called the Phillips Roadmap Cipher.

The Z32 Phillips Roadmap Cipher

The Z32 Cipher is contained in a letter from Zodiac, sent to the San Francisco Chronicle on June 26, 1970. The letter is shown in Figure 1.

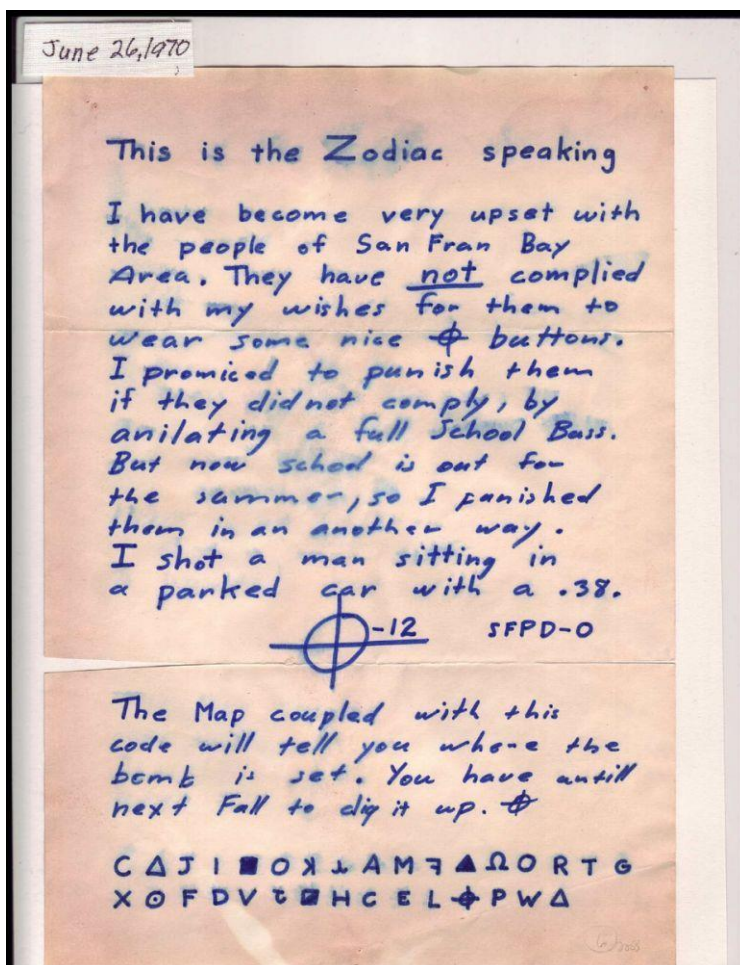


Figure 1 – Z32 Letter

The same letter contained a portion of a Phillips 66 Roadmap. The map is shown in Figure 2. Zodiac claims that the map and code may be used to find the location where a bomb has been set.



Figure 2 – The Phillips 66 Roadmap

On July 26, 1970, Zodiac mailed a long, five-page letter to the San Francisco Chronicle. This letter included further admonishments about people wearing Zodiac buttons, a long reference to a Gilbert and Sullivan operetta, and the post-script shown in Figure 3.

Figures 1 through 3, then, comprise all the information which the Zodiac has provided regarding the Z32 Cipher.

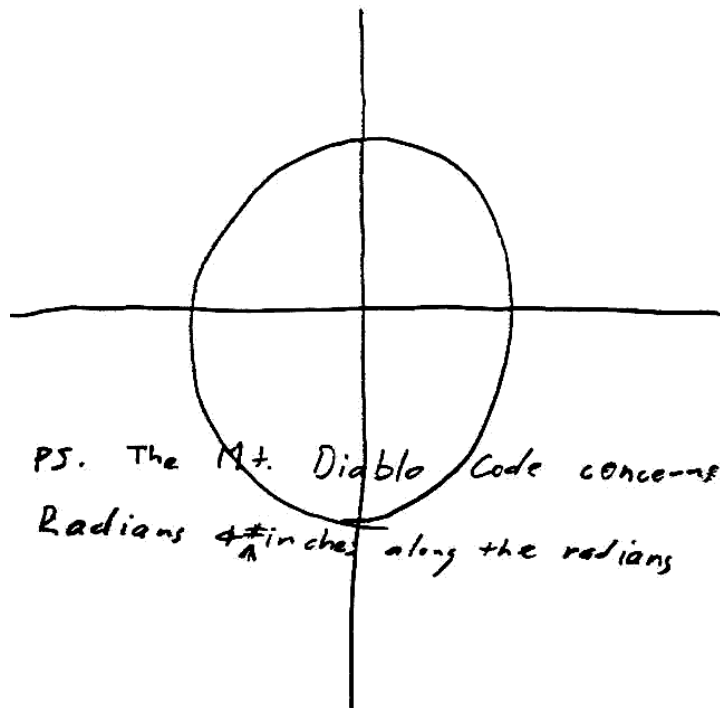


Figure 3 – Post-Script to July 26, 1970 Letter

Polar Coordinates

Before digging into the artifacts that the Zodiac provided, we need to take a brief detour to discuss polar coordinates. In the 1960's, this information would have been taught at the high school level, either in an Algebra II class, a Trigonometry class, or possibly in a Pre-Calculus class.

Given a two-dimensional surface (like the Phillips 66 map), there are two ways of locating a specific point of interest. The first, more commonly used way is via Cartesian Coordinates. In this system, a point is located by specifying its offset from a reference point, both horizontally and vertically. For instance, in Figure 4, we locate the point that is 12 units to the right and 5 units up from reference point 0.

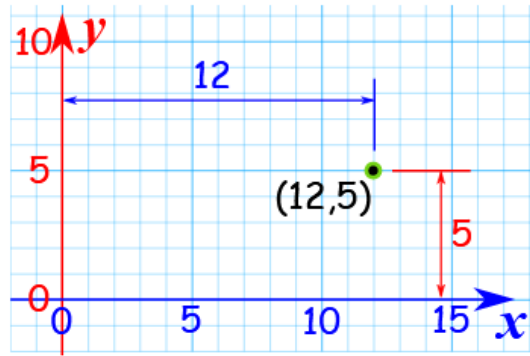


Figure 4 – Example of Cartesian Coordinates

A second system, called Polar Coordinates, locates points in a different way. To specify a point in Polar Coordinates, you must specify an angle from a reference axis, and a distance from a reference point along that angle. For example, Figure 5 shows the same point that was located in Figure 4. However, in this case, it is located by specifying that it is at an angle of 22.6° from the horizontal, at a distance of 13 units from the 0 reference point.

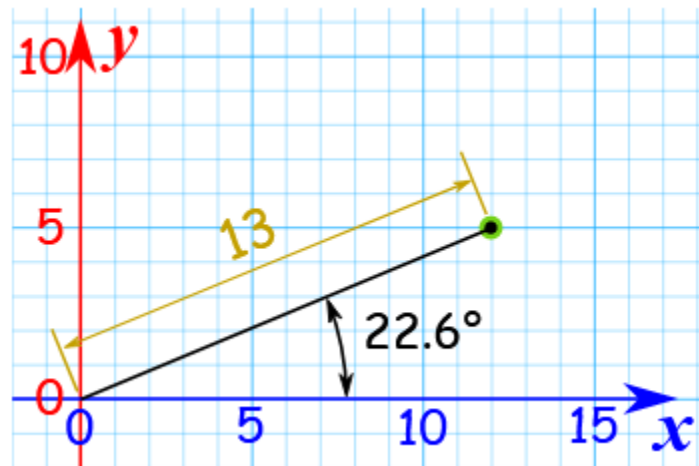


Figure 5 – Example of Polar Coordinates

The Post-Script

The post-script of the July 26, 1970 letter reads:

PS. The Mt. Diablo code concerns Radians & # inches along the radians

This certainly sounds like Zodiac is telling us that he used polar coordinates. If he had substituted the word “angle” for “radians”, he would have been precisely describing a polar coordinate system.

A radian is an angle measurement that is commonly used in trigonometry and calculus. A high school student in the 1960's would probably first encounter radians in a trigonometry or pre-calculus class. There are 2π radians in a complete circle. A radian is approximately equal to 57.3 degrees.

Does the Zodiac really mean "radians"? Or is he using "radians" as a synonym for an arbitrary angle measurement? We will come back to this question later – there is insufficient information in the post-script to answer it.

The distance measurement to be used is pretty clear, though. Distances are to be measured in inches. This is presumably inches as measured on the Phillips 66 map. (According to the key on the map, 1 inch approximately equals 6.4 miles.)

So, to sum up – the post-script tells us that the location of interest on the map is identified with polar coordinates. We would therefore expect the cipher to contain two numbers. One number would represent the distance from a reference point on the map to the location of interest, in map inches. The second number would represent the angle at which the location of interest could be found. This angle *might* be in radians, though this detail is a bit less certain.

The Map

The map provides further information that will help find the location that the Zodiac is trying to call our attention to.

First of all, it establishes a pretty clear reference point and reference axes. The reference point is clearly indicated to be the little "X" on the map that represents Mt. Diablo. The axes are to be aligned with magnetic north.

Note that, in 1970, in the San Francisco area, magnetic north was located about 17 degrees clockwise from true north. (The angle varied by a couple tenths of a degree depending on where in the area you were located, but 17 degrees was a typical value.)

The map diagram also shows us very specifically where we should measure our location angle from. The diagram shows the 0 angle as coinciding with magnetic north, with the angle increasing as we rotate clockwise.

When we consider the angle markings around the blue circle on the map, though, we run into a discrepancy. These markings imply that, in the Zodiac's system, a full circle has 12 divisions.* These divisions are NOT equal to radians.

The map thus shows us an angular measurement that does not equal the measurement mentioned in the post script. At this point it is unclear – does the Zodiac mean to use radians as his angular measure? Does he mean to use a number from 0 to 12? It is also possible that he is using the 0 to 12 system but calling each division in this system a radian, even though this is not technically correct, simply because there is no other word for such a division.

* The similarity to a clock face is apparent. This is especially interesting since the Zodiac may have taken his name and symbol from a watch.

Location Uncertainty

As discussed above, it seems very likely that the Z32 Cipher contains 2 numbers – a distance measurement, in inches, and an angular measurement, either in radians or in the 0 to 12 system shown on the Phillips 66 map. We must briefly address the ways in which the Zodiac would have performed these measurements, and the measurement uncertainty associated with them.

Distance:

Zodiac almost certainly performed the distance measurement on the Phillips 66 map with a standard ruler. A standard ruler is marked every 1/16 inch. Thus, if Zodiac performed the measurement very carefully*, we would still not be surprised if he made a measurement error of $\pm 1/16$ inch.

Note that this fact – that the Zodiac probably used a standard ruler to measure distance – gives us a further clue about one of the numbers we are looking for in the cipher. In all probability, the distance measurement is expressed as a mixed number, rounded to the nearest 1/16 inch. For instance, TWO AND THREE SIXTEENTHS or FOUR AND ONE HALF would be distances that Zodiac could have easily measured. SIX AND ONE SEVENTH or ONE POINT ONE EIGHT would not be, and probably do not appear in the Z32 Cipher.

Angle:

I can think of two ways in which Zodiac may have made the angle measurement.

First, he might have made the measurement directly from the top of Mt. Diablo. Once he had reached the top, he could have used a compass to find magnetic north. He could then have aligned his watch such that the “12” was pointed in the same direction as the compass. He could then have determined which number was pointing in the direction that coincided with the direction of his desired location.

This would have resulted in an extremely coarse measurement, but it would explain why he needed to base his coordinates on magnetic north. On top of Mt. Diablo, it would be very difficult to determine exactly where true north is. However, with a compass, it would be very easy to locate magnetic north.

It is also possible that Zodiac determined his angle measurement by measuring on the Phillips 66 map with a protractor, and then converting the result into either radians or into the 0 to 12 system. In this case, a great deal more accuracy would be expected. A standard protractor is marked every degree. So, if Zodiac did a very careful job of measuring, we would still not be surprised if he made a measurement error of ± 1 degree.

Note that the direction of magnetic north is not exactly 17 degrees in the San Francisco area. It varies throughout the area, from a little above 17 degrees to a little below. The uncertainty in the direction of magnetic north could add a few tenths of a degree to the error.

* It may be unreasonable to assume that Zodiac made these measurements with any degree of precision. He seems to have made careless mistakes in the encoding of the Z408 Cipher. For instance, there are two symbols – one representing the letter S and the other representing the letter A – that he confuses in several places. He may have been similarly sloppy in the construction of the map puzzle. However, for now, let's assume he was reasonably meticulous.

Possible Locations

The June 26, 1970 letter indicates that a bomb has been buried at the location indicated in the cipher. Zodiac made several bomb threats, yet there is no evidence of his ever creating or detonating any bomb. The bomb threats appear to have been made in order to create fear and garner publicity, and without any real intention of following through.

So it seems unlikely that the Z32 Cipher provides the location of a bomb. Instead, the location hidden within the cipher is more likely to be some place of interest to the Zodiac. For instance, it could be the location of one of his crimes, possibly one that had not yet been discovered by the police. If Zodiac was feeling cocky and believed that his cipher would never be solved, it could even be his home address.

At this point in the analysis, my plan was to examine several locations of importance to the Zodiac case. I would determine the polar coordinates of each one, and then look to see if these coordinates could possibly be encoded in the Z32 Cipher. I would continue until I found a location that was consistent with an elegant solution of the Cipher (one that sounded like it had a fair chance of being correct).

As it turned out, the very first location I tried ended up meeting this criterion. That location was Arthur Leigh Allen's home address.

Arthur Leigh Allen's House

Arthur Leigh Allen was suspected by police starting in 1971. He is the only suspect from the actual time of the murders that I am aware of, though I am certain that the police must have investigated other people.

Allen was a significant suspect for a while. This is because there was a great deal of circumstantial evidence pointing toward him, he made some strange and incriminating statements during his first interview with police, and he was known to be a serial child molester. However, none of the forensics linked him to the crimes – fingerprints, handwriting, or even a DNA test that was performed much later, after the technology had been developed. He was never arrested for anything in connection with the Zodiac case.

My personal opinion – and it is only my *opinion* – is that it is unlikely that Allen was the Zodiac killer. However, among all the suspects I have read about, I think he is the probably the *most* likely. (I am certain others disagree with me about this, and I don't pretend to be all that well informed on this point.)

So, as the first location to investigate, I chose his house. Maybe the Zodiac wasn't leading police to a bomb. Maybe the fact that no-one had solved his Z340 Cipher had made him cocky, and he decided to encode a set of directions to his front door.

Arthur Leigh Allen lived with his parents at 32 Fresno St., in Vallejo. I used Google Maps to locate this address – see Figure 6.



Figure 6 – 32 Fresno St., in Vallejo (per Google Maps)

Looking at the Phillips 66 map, it's clear that the area has changed since 1969, and finding this location on the Phillips map requires a lot of staring at the maps and comparing them. Figure 7 locates the 32 Fresno St. address on the Phillips 66 map – just barely inside the boundaries of the map.



Figure 7 – Locating 32 Fresno St. on the Phillips 66 Map

From here, it's a simple matter to determine the angle from magnetic north and the distance from the "X" on the map at Mount Diablo. See Figure 8.

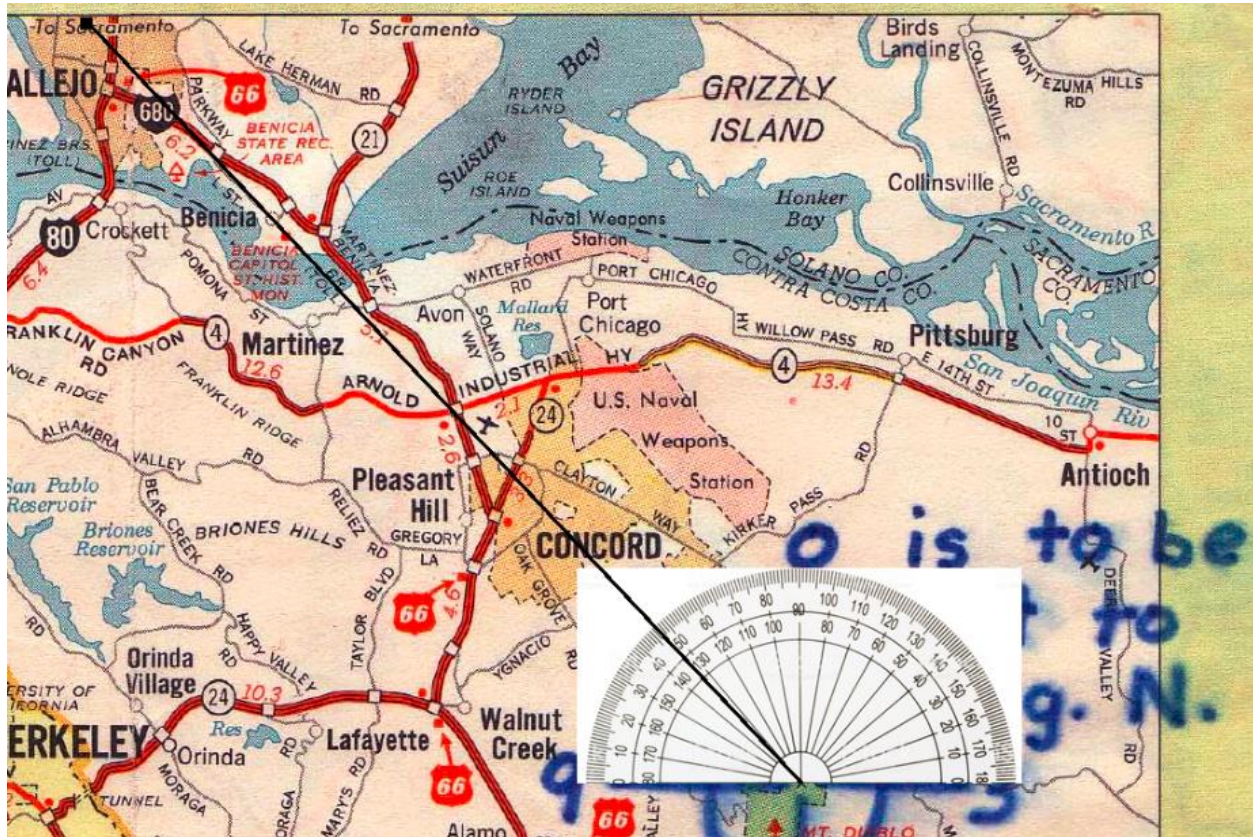


Figure 8 – Measuring the Coordinates of 32 Fresno St.

I used a simple protractor to measure the angle. It turns out to be 317° from true north (as we go in the clockwise direction, as directed by Zodiac). This is 300° from magnetic north, *which corresponds precisely to the ten o'clock position.* (For reference, this is equivalent to 5.24 radians.)

As for the distance measurement, this was a little more difficult for me than it was for the Zodiac. I do not have an original version of the map to work from. Instead, I downloaded a copy from the following link: <http://www.zodiackiller.com/HugeMap.html>. When I displayed this map on my computer screen, it was on a different scale from the original scale of 1 inch = 6.4 miles. So I needed to do some simple math to account for the different scales.

There are 3 quantities of interest in this calculation. They are defined as follows:

- Screen inches: Distance, in inches, as measured on my computer screen
- Map inches: Distance, in inches, as measured on the original Phillips 66 map
- Miles: Distance, on the ground, in miles

* Note: If we go counterclockwise, instead of clockwise, 32 Fresno St. is about 1.05 radians from magnetic north.

I displayed the map on my screen, and measured the length of the 8-mile scale in the lower left corner of the map in screen inches. From this, I could determine the number of miles per screen inch. I then measured the distance from Mt. Diablo to 32 Fresno St. in screen inches, and converted to miles. Then, using the conversion 1 map inch = 6.4 miles, I was able to convert the mile measurement to map inches.

On my screen, 2.795 inches equaled 8 miles. The distance from Mt. Diablo to 32 Fresno St. was 7.52 screen inches. By the process outlined above, this is equivalent to 3.36 map inches. Remember, though, that the Zodiac probably measured this distance with a standard ruler, so his measurement is probably rounded to the nearest sixteenth of an inch. To the nearest sixteenth of an inch, 3.36 inches rounds to three and three eighths inches.

The Cipher

Next, we turn our attention to the cipher. Could the coordinates determined above be hidden within it?

Based on the earlier discussion, a strong solution to the cipher would contain the following:

- Two numbers – one representing a distance measurement and one representing an angular measurement
- Simple homophonic substitution
- The distance measurement is in inches
- The distance measurement is probably expressed as a fraction which is rounded to the nearest one-sixteenth
- The angular measurement is either in radians or in a “0 to 12” clock system
- The word “inch” (or “inches”, or the abbreviation “in”) and the word “radian” (or “radians”, or the abbreviation “rad”) are likely to appear in the plaintext

Can a solution to the cipher be found that satisfies these criteria while pointing to the coordinates we have established?

The answer is yes, and in a pretty straightforward way. Figure 9 shows the decoding. Table 1 provides the cipher key. The plaintext message is:

IN: THREE AND THREE EIGHTHS
 RADIANS: TEN

I N T H R E E A N D T H R E E E I
 C Δ J I ■ O X J A M 7 ▲ Ω O R T G
 X ⊙ F D V τ ■ H C E L ⊕ P W Δ
 G H T H S R A D I A N S T E N

Figure 9 – Decoding of Z32 Cipher (Homophonic Substitution)

Table 1 – Cipher Key

Cipher Text	Plain Text	Cipher Text	Plain Text	Cipher Text	Plain Text
⋈	A	×	G	Ω	R
◼	A	⊙	H	■	R
E	A	▲	H	⋈	R
M	D	D	H	V	S
H	D	I	H	⊕	S
R	E	G	I	J	T
T	E	C	I	Ǝ	T
O	E	A	N	P	T
K	E	Δ	N	F	T
W	E	L	N		

Conclusions

One wholly self-consistent solution of the Z32 Cipher is that it leads precisely to Arthur Leigh Allen’s home address.

Note: I find this solution compelling, because the plaintext solution is simple, direct, and makes logical sense in context. Furthermore, it aligns with all the criteria for a strong solution that were outlined above. *However, it must be stressed that this is not necessarily a unique solution.* Since the Z32 Cipher only contains 3 repeated characters, other solutions may exist which are equally strong or even stronger. This solution is compelling, but not definitive.